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THE NAVAL AVIATOR'S SPEECH DISCRIMINATION TEST:
INSTRUMENTATION AND TECHNIQUE

James W. Greene

Naval Aerospace Medical Institute
Pensacola, Florida

December 1967

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NAVAL AEROSPACE MEDICAL INSTITUTE
NAVAL AEROSPACE MEDICAL CENTER
PENSACOLA, FLORIDA

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INSTRUMENTATION AND TECHNIQUE

James W. Greene

Bureau of Medicine and Surgery
MF022.03.02-5021

Approved by

Ashton Graybiel, M. D.
Director of Research

Released by

Captain J. W. Weaver, MC USN
Commanding Officer

6 December 1967

NAVAL AEROSPACE MEDICAL INSTITUTE
NAVAL AEROSPACE MEDICAL CENTER
PENSACOLA, FLORIDA 32512

SUMMARY PAGE

THE PROBLEM

The Naval Aviator's Speech Discrimination Test was formulated in 1964 and has been utilized by the Bureau of Medicine and Surgery in evaluating aviators who fail to meet the hearing standards for aviation. A survey of equipment used in the Navy's Hearing Conservation Program revealed that no suitable device existed for administering this test.

FINDINGS

Two similar systems of test presentation have been developed and are in current use at eighteen Navy and Marine Corps installations. These devices produce the properly controlled test materials for the Naval Aviator's Speech Discrimination Test and are easily operated by trained corpsmen.

INTRODUCTION

For several years prior to 1964 the Navy was faced with the problem of losing the services of its senior aviators who, by the nature of their duties, had sustained a hearing loss exceeding the physical standards. It was reasonable to request waivers for such hearing losses since the men showed no apparent loss in ability to communicate and were otherwise highly qualified. Since an objective test was necessary to provide a sound basis for such waivers, the Naval Aviator's Speech Discrimination Test (NASDT) was formulated as requested by the Bureau of Medicine and Surgery and was validated in 1964 (1). Since that time, the test has been utilized for further evaluation of aviators who fail to meet the hearing standards for aviation.

The nature of the test, which involves a listening task for high-level speech signals with a simulated noise background, requires some form of speech audiometer or modified tape recorder and earphone configuration. The high speech levels of 115 db sound pressure level (SPL) preclude the use of all but the most sophisticated diagnostic audiometers. In order to make the test accessible to the majority of aviation activities a system utilizing a tape cartridge player was developed. Two similar systems of test presentation are now in current use at eighteen Navy and Marine Corps installations. This report presents the considerations which led to the development of the two systems, and additional information is included to enable the user of either system to administer the test properly.

BACKGROUND

The task of maintaining voice communications in the aircraft cockpit requires listening to high-level speech signals with a high ambient noise background. Many aviators with thousands of hours' flight time, primarily in propeller-type aircraft, have a characteristic "notch" or loss of hearing in the higher audiometric frequencies. It has been found (1), however, that there is no consistent relationship between the aviator's ability to understand speech at high levels in a noise background and the configuration of the pure-tone threshold audiogram currently used to evaluate hearing acuity. Indeed, many aviators who have extensive hearing losses as determined by audiometric evaluation show no loss in their speech discrimination for words presented in a simulated cockpit environment.

The NASDT is a test to determine the aviator's ability to understand speech signals embedded in a background of aircraft noise. This test is used as the basis for issuing waivers for hearing losses which exceed the standards. The NASDT, therefore, provides the Bureau of Medicine and Surgery with a means of evaluating the aviator's hearing capability in terms of the operational environment as opposed to the application of a fixed standard of physical fitness.

GENERAL DESCRIPTION OF TEST

The test signals which comprised the NASDT were a list of 100 one-syllable words mixed with a background of aircraft noise. The word lists are "phonetically balanced" (PB) words taken from disc recordings originally produced by the Central Institute for the Deaf and used as Auditory Test W-22 (2). These discs were re-recorded on a master tape system. The particular noise used in this test was a recording of the inflight noise from a UC-45J aircraft in normal cruise. The word lists and noise tapes were mixed to produce a master tape used for the preparation of identical copies for the playback units. Due to the particular vowel-to-consonant ratio of speech signals on these voice recordings and the aircraft noise spectrum, a signal-to-noise ratio of +15 db was established as the desired relationship. That is, the speech peaks were set 15 db above the background noise level. This ratio was monitored during the recording and copying process on a Brüel & Kjær Model 2305 Level Recorder which showed the root-mean-square value of noise level relative to the speech peaks.

APPARATUS

THE REVERE M-3 SYSTEM

One of the systems in use for the NASDT is the Revere M-3 tape cartridge player (Figure 1) which handles the cartridge automatically. Certain minor changes were made to prevent mishandling or incorrect operation; e.g., the rewind and repeat controls were disabled, the tone and volume controls locked, and the loud speakers removed. A group of earphone driver units were selected for uniform frequency response at the operating level of the test. Pairs of phones were matched within 2 db for each instrument. Since the Revere M-3 System tape was of nonstandard width, copies of the master tape were recorded on a Revere M-2 tape cartridge recorder. All machines were then aligned and a level recording made for detection of tape flaws and recording level changes. To aid the user of this system, Appendix A presents the detailed procedure for the test and troubleshooting information for the equipment operator.

THE COUSINO AR-7328 SYSTEM

Another system currently used for the NASDT is the Cousino AR-7328 Audio Repeater tape cartridge player (Figure 2). This device is much simpler than the Revere M-3 and provides tape reproduction within acceptable limits for the test. The tape cartridge is of the endless-loop type. A foil sensing strip at the end of the test recording automatically shuts the machine off. As in the case of the Revere M-3, the volume controls were locked and the loud speakers removed. Appendix B contains the detailed procedure and technical information for this system.



Figure 1
Photograph of Revere M-3 System



Figure 2
Photograph of Cousino AR-7328 System

SYSTEM CALIBRATION

After the modifications were made and the machines were "run in" for many hours, each system was calibrated with its own headset and tapes. A Brüel & Kjær Model 2203 Sound Level Meter, used with a standard earphone coupler, was set to the "fast" meter speed and the "C" weighting response. The earphone was placed over the coupler, and the volume control of the tape player was adjusted so that the background noise averaged 100 db SPL, and the speech peaks, approximately 115 db SPL. Because the PB words have different acoustical levels for the vowel sounds, the speech peaks actually varied from 105 db to 118 db SPL.

METHOD OF TEST ADMINISTRATION

Any aviator who fails to meet the minimum hearing standards as prescribed in the Manual of the Medical Department (3) should be given the NASDT form 1A2A. He should be apprised of the test and arrangements made to take the test at one of the installations listed in Appendix C. The procedures and instructions to the subject are given in Appendix D. These instructions may be reproduced and handed to the subject prior to the test.

SCORING THE TEST AND REPORTING THE DATA

A list of the correct responses to each of two forms (1A2A and 1B2B) of the test is provided with each machine and is presented in Appendix E. These answer sheets should be kept in a safe place, and subjects should not be allowed to see them either before or after taking the test. Subjects must not be told the correct responses to test items, as this may aid them in taking the test in the future. For the same reason, subjects should not be allowed to see the scoring process.

Each word counts one percentage point. In order for a response to be graded as correct, the exact sound of the word must be written. Incorrect spelling will not be cause for marking a response incorrect if the sounds are properly represented. For example, "sea," "see," and "c" are acceptable, but the plural "seas" is incorrect. The answer sheet shows some of the commonly used acceptable variations in spelling, but there may be others which do not appear there.

A score of 70 per cent constitutes a passing grade. If the aviator's score is 70 per cent or better, this grade is reported to the Bureau of Medicine and Surgery, and a waiver is requested. If he fails to attain a grade of 70 per cent, he is re-tested the following day by using form 1B2B. Both scores are reported, and if the second reaches the required 70 per cent, waiver is requested.

Whenever the NASDT is administered, the score should be entered on the aviator's BuMed Form 88, Section 73, along with the date and place the test was taken. Under

section 74, a note is made of the loss but indicating that the aviator passed NASDT. (Example: "71. Perceptive hearing loss -- Passes NASDT-NCD if BuMed approves waiver.")

The Naval Aviator's Speech Discrimination Test form (NAMI Form 6500/1) must be filled out completely, including current audiometric data. This form is then folded and stapled for mailing to the Naval Aerospace Medical Institute. If the pure tone audiogram was performed on an automatic audiometer, the audiogram card should be stapled inside the folded NAMI Form 6500/1 and mailed along with it.

CONCLUSION

The nature of the test signals for the NASDT requires some type of speech and noise reproduction. A complete diagnostic audiometer with tape playback facilities could have been utilized, but many naval air installations do not have easy access to such equipment, and corpsmen with the required degree of training and experience are not readily available.

The two systems described here for the test are reliable and not difficult to operate. Should the need for maintenance arise, the units can be shipped as easily as an audiometer. Requests for information and maintenance should be directed to the Naval Aerospace Medical Institute.

REFERENCES

1. Bragg, V. C., and Greene, J. W., A proposed speech discrimination test for senior naval aviators. Aerospace Med., 35: 525-532, 1964.
2. Central Institute for the Deaf, Auditory Test W-22. Phonetically-Balanced Word Lists. Description and Instructions for Use. Undated.
3. U. S. Navy, Manual of the Medical Department. Chapter 15, Article 64, 1957. p 44.

APPENDIX A

Test Procedure for Revere M-3 System

TEST PROCEDURE FOR REVERE M-3 SYSTEM

1. Press ON-OFF switch. Motor should start running and pilot light should come on. After a five-minute warm-up period, machine is ready to use.
2. Seat the subject and give him a blank form (NAMI 6500/1) and a pen. Have him fill in identifying information and flight time.
3. Give instructions: e.g., "This is a test in which you are required to distinguish various words in the presence of aircraft noise. The test items are familiar one-syllable words. Each is preceded by the phrase 'you will say . . .'. Listen carefully for the test word that follows. Print the word you hear or think you hear. Do not leave any blank spaces."
4. Place headset on the subject, red phone on the right ear, making sure that both ears are covered during the entire test.
5. Press PLAY button. Make sure that the subject is writing words.
6. At the end of the test, press REJECT knob to the left. Machine will rewind and re-cycle. Do NOT disturb machine while it is re-cycling. When tape has rethreaded, counter should move slowly.
7. After tone sounds, press STOP button. Machine may now be turned off (press ON-OFF switch) or left on for next subject.

TROUBLESHOOTING

If no sound is heard from earphones:

1. Check to see that recorder is ON and earphone plug is pushed all the way in.
2. If not corrected, remove earphone plug from Left Channel jack and insert into Right Channel jack.
3. If not corrected and tape has threaded (see next trouble check), earphones may be defective.

If tape does not thread itself (counter is running too fast and no tone is heard):

1. Open top cover, carefully pull REJECT arm toward you, twist function dial one notch clockwise to END REWIND position, and press REJECT arm again.

2. If not corrected, repeat above action.
3. If not corrected, repeat above action, but lift cartridge off cartridge table when it rises. Then, place other cartridge (1B2B) on table, and use it instead of the first.

INSTALLATION

Testing may be carried out in any office which is free of obvious distractions. The power requirements are 110-120 volts, 60 cps AC, 1 ampere. The initial setting up procedure is as follows:

1. Unpack the recorder, earphones, and tapes. CAUTION--Do not allow tapes to remain within 6 feet of any magnetic fields of equipment such as X-ray transformers, electric motors, ECG machines, etc.
2. Insert black power cord into connector at rear of recorder.
3. Connect other end to 110-volt outlet.
4. Insert earphone plug into jack at rear marked External Speaker--Left Channel.
5. Place tape cartridge face up on left cartridge table.
6. Press ON-OFF switch. Motor should start running and pilot light should come on.
7. Press PLAY button. Cartridge should drop down, thread itself, and cycle the indicator to PLAY. Note that the counter is now turning slowly. A tone should be heard from the earphones.
8. When the tone ends, press the STOP button.
9. To turn off machine, press ON-OFF switch.

APPENDIX B

Test Procedure for Cousino System

TEST PROCEDURE FOR COUSINO TAPE SYSTEM

1. Seat the subject and give him the blank form (NAMI 6500/1) and a pen. Have him fill in identifying information and flight time.
2. Give instructions: e.g., "This is a test in which you are required to distinguish various words in the presence of aircraft noise. The test items are familiar one-syllable words. Each is preceded by the phrase 'you will say ...' Listen carefully for the test word that follows. Print the word you hear or think you hear. Do not leave any blank spaces."
3. Place headset on the subject, red phone on the right ear, making sure that both ears are covered during the entire test.
4. Move the POWER SWITCH quickly from START to RUN. Make sure that the subject is writing words.
5. At the end of the test, the machine will stop automatically. Remove the earphones from the subject.

TROUBLESHOOTING

If no sound is heard from earphones:

1. Check to see that the power cord is plugged in and that the earphone plug is pushed all the way into its socket.
2. Move power switch to START, then move switch quickly to RUN. Note: Moving this switch too slowly (or too rapidly) will cause machine to stop. Practice will correct this problem.
3. When changing cartridges, pull the cartridge on the machine toward you gently, but firmly. Before inserting another cartridge, make sure that the cartridge holder is all the way out. Place new cartridge in holder and push firmly in until the second stop detent is felt.
4. If necessary, remove fluted cover and inspect for rotation of capstan and flywheel. Observe tape position in head guide assembly.
5. Every 20 times this machine is used, gently clean head, tape guides, capstan, and pinch roller with a Q-tip moistened in isopropyl alcohol or tape head cleaner. Caution: Do not use acetone, xylene, carbon tetrachloride, or absolute alcohol, and do not use too much pressure on tape head.

INSTALLATION

Testing may be carried out in any office or space which is free of obvious distractions. An audiometric testing booth can be used, but is not necessary. The power requirements are 110-120 volts, 60 cps AC, 1 ampere. The initial setting up procedure is as follows:

1. Unpack the recorder, earphones, and tape cartridges. CAUTION: Do not allow tapes to remain within 6 feet of any magnetic fields such as produced by X-ray transformers, electric motors, ECG machines, etc.
2. Connect power cord to 110-volt outlet.
3. Insert earphone plug into jack marked EXTERNAL SPKR. Be sure to push plug all the way in.
4. Insert the tape cartridge into the guides and push cartridge in until the second stop detent is felt.
5. Move power switch to START, then quickly to RUN. Tape should move and in several seconds the introductory announcement will begin.
6. At the end of the test, the machine will automatically turn off. The machine may be left as is, or the switch returned to OFF as desired.

APPENDIX C

Locations of NASDT Installations

LOCATIONS OF NASDT INSTALLATIONS

NAMI, Pensacola, Fla.
NAS, Quonset Point, R. I.
NAF, Andrews, Wash.
NAS, Norfolk, Va.
NAS, Oceana, Va.
MCAS, Cherry Point, N. C.
NAS, Cecil Field, Fla.
NAS, Sanford, Fla.
NAS, Glenview, Ill.
NAS, North Island, Calif.
NAS, Imperial Beach, Calif.
MCAS, El Toro, Calif.
NAS, Miramar, Calif.
NAS, Lemoore, Calif.
NAS, Pt. Mugu, Calif.
NMC, Pt. Mugu, Calif.
NAS, Whidbey Island, Wash.
NAS, Barber's Point, Hawaii

APPENDIX D

Instructions to Subject

INSTRUCTIONS TO SUBJECT

This test is designed to determine how well you can understand certain test words which have been recorded with airplane-type noise. The test consists of 100 one-syllable words. Each test word is preceded by the phrase, "You will say, . . ." You are to print only the word which follows this phrase. Specific instructions follow:

1. Once the headset is in place, do not move it. Both ears should be covered at all times.
2. When the tape begins, you will hear an introductory sentence, followed by the list number (1A2A or 1B2B). Write this number in the appropriate space on your paper.
3. Listen carefully to the speaker; try to print the words exactly as you hear them. The words will always be loud enough, but they must be recorded exactly as they sound. Print only one word in each space.
4. You will have approximately six seconds to write after each word is given. Spelling is not important, except that it must depict the proper sounds. For example, "to," "too," and "two" are acceptable spellings, but "an" is not acceptable if the word was "and."
5. If you are not sure of a word, print what you think you heard. Do not leave any blank space.
6. There is a pause after each twenty-five words (at the end of each column). This will let you know where you are, even though the speaker does not identify the words by number.

APPENDIX E

Word Lists for Scoring Test

NAVAL AVIATOR'S SPEECH DISCRIMINATION TEST
NAMI 6500/1 (4-65)

Please fill all blanks

NAME		RANK	FILE NUMBER OR ID	DATE
AGE	BIRTH DATE	DESIGNATION (Job)		DATE DESIGNATED NAVAL AVIATOR
SERVICE		DATE LAST IN SERVICE GROUP 1		TOTAL FLIGHT TIME
LIST 1A2A		SCORE		REPORTING FACILITY

1. AN	26. YOU (EWE)	51. YOUR (YORE)	76. AND
2. YARD	27. AS	52. BEEN (BIN)	77. YOUNG
3. CARVE	28. WET	53. WAY (WEIGH)	78. CARS
4. US	29. CHEW	54. CHEST	79. TREE
5. DAY	30. SEE (SEA)	55. THEN	80. DUMB
6. TOE	31. DEAF	56. EASE	81. THAT
7. FELT	32. THEM	57. SMART	82. DIE (DYE)
8. STOVE	33. GIVE	58. GAVE	83. SHOW
9. HUNT	34. TRUE	59. PEW	84. HURT
10. RAN	35. ISLE (AISLE)	60. ICE	85. OWN
11. KNEES	36. OR (OAR)	61. ODD	86. KEY
12. NOT (KNOT)	37. LAW	62. KNEE	87. OAK
13. MEW	38. ME	63. MOVE	88. NEW (KNEW)
14. LOW	39. NONE	64. NOW	89. LIVE (VERB)
15. OWL	40. JAM	65. JAW	90. OFF
16. IT	41. POOR	66. ONE (WON)	91. ILL
17. SHE	42. HIM	67. HIT	92. ROOMS
18. HIGH	43. SKIN	68. SEND	93. HAM
19. THERE (THEIR)	44. EAST	69. ELSE	94. STAR
20. EARN (URN)	45. THING	70. TEAR (TARE)	95. EAT
21. TWINS	46. DAD	71. DOES	96. THIN
22. COULD	47. UP	72. TWO (TOO, TO)	97. FLAT
23. WHAT	48. BELLS	73. CAP	98. WELL
24. BATHE	49. WIRE	74. WITH	99. BY (BUY, BYE)
25. ACE	50. ACHE	75. AIR (HEIR)	100. AIL (ALE)

FLIGHT EXPERIENCE (Civilian & Military)															
NAVY								CIVILIAN							
MODEL															
FLIGHT HOURS															

AUDIOGRAM (Fill out completely and attach original form)															
RIGHT								LEFT							
DATE	250	500	1000	2000	3000	4000	6000	250	500	1000	2000	3000	4000	6000	EXAMINER & DATE
AIR															
BONE															

NAVAL AVIATOR'S SPEECH DISCRIMINATION TEST
NAMI 6500/1 (4-65)

Please fill all blanks

NAME		RANK	FILE NUMBER OR ID	DATE
AGE	BIRTH DATE	DESIGNATION (Job)		DATE DESIGNATED NAVAL AVIATOR
SERVICE		DATE LAST IN SERVICE GROUP 1		TOTAL FLIGHT TIME
LIST	182B	SCORE		REPORTING FACILITY

- | | | | |
|------------------|----------------|-----------------|-------------------|
| 1. CARVE | 26. DAD | 51. WAY (WEIGH) | 76. AIL (ALE) |
| 2. WIRE | 27. STOVE | 52. BY (BUY) | 77. CHEST |
| 3. FELT | 28. ACHE | 53. SMART | 78. THIN |
| 4. THING | 29. US | 54. EAT | 79. GAVE |
| 5. KNEES | 30. HIM | 55. ODD | 80. ROOMS |
| 6. POOR | 31. NOT (KNOT) | 56. ILL | 81. KNEE |
| 7. OWL | 32. ME | 57. JAW | 82. SEND |
| 8. LAW | 33. IT | 58. OAK | 83. ONE (WON) |
| 9. THEIR (THERE) | 34. SEE (SEA) | 59. ELSE | 84. HURT |
| 10. GIVE | 35. EARN (URN) | 60. SHOW | 85. TARE (TEAR) |
| 11. WHAT | 36. TRUE | 61. CAP | 86. DUMB |
| 12. CHEW | 37. BATHE | 62. TREE | 87. WITH |
| 13. AS | 38. YOU (EWE) | 63. YOUNG | 88. AND |
| 14. TWINS | 39. WET | 64. AIR (HEIR) | 89. CARS |
| 15. ISLE (AISLE) | 40. COULD | 65. THAT | 90. TOO (TWO, YO) |
| 16. ACE | 41. THEM | 66. DOES | 91. FLAT |
| 17. DEAF | 42. HIGH | 67. OWN | 92. NEW (KNEW) |
| 18. SHE | 43. OR (OAR) | 68. HIT | 93. KEY |
| 19. NONE (NUN) | 44. LOW | 69. LIVE (VERB) | 94. NOW |
| 20. MEW | 45. JAM | 70. MOVE | 95. OFF |
| 21. SKIN | 46. RAN | 71. HAM | 96. ICE |
| 22. HUNT | 47. EAST | 72. PEW | 97. STAR |
| 23. UP | 48. TOE | 73. DIE (DYE) | 98. EASE |
| 24. DAY | 49. BELLS | 74. THEN | 99. WELL |
| 25. AN | 50. YARD | 75. YORE (YOUR) | 100. BIN (BEEN) |

FLIGHT EXPERIENCE (Civilian & Military)											
NAVY						CIVILIAN					
MODEL											
FLIGHT HOURS											

AUDIOGRAM (Fill out completely and attach original form)																	
	RIGHT								LEFT								
DATE	250	500	1000	2000	3000	4000	6000	8000	250	500	1000	2000	3000	4000	6000	8000	EXAMINER & DATE
AIR																	
BONE																	

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14 KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
Speech discrimination						
Tape cartridge reproducer						
Hearing tests						
Aviator's hearing standards						
High-intensity speech reception						
Aircraft cockpit aural simulation						